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(54) **Centrifugal separator**

(57) A separator suitable for separating a crude oil feed containing gas into gas and liquid comprises a vessel having an inlet 7 for feed disposed so that feed introduced under a pressure gradient is caused to form a downwardly flowing vortex of enhanced liquid from which gas separates, an upper outlet 4 for the gas comprising a conduit extending downwardly into the vessel from the top thereof referred to as a vortex finder, a lower outlet for the enhanced liquid, and wherein the vortex finder has a baffle assembly 3 associated therewith, said baffle assembly being rotatable about a vertical axis. The baffle assembly 3 can be rotatable relative to the vortex finder. The vortex finder may be connected to a gas scrubber for removing oil droplets from the gas.

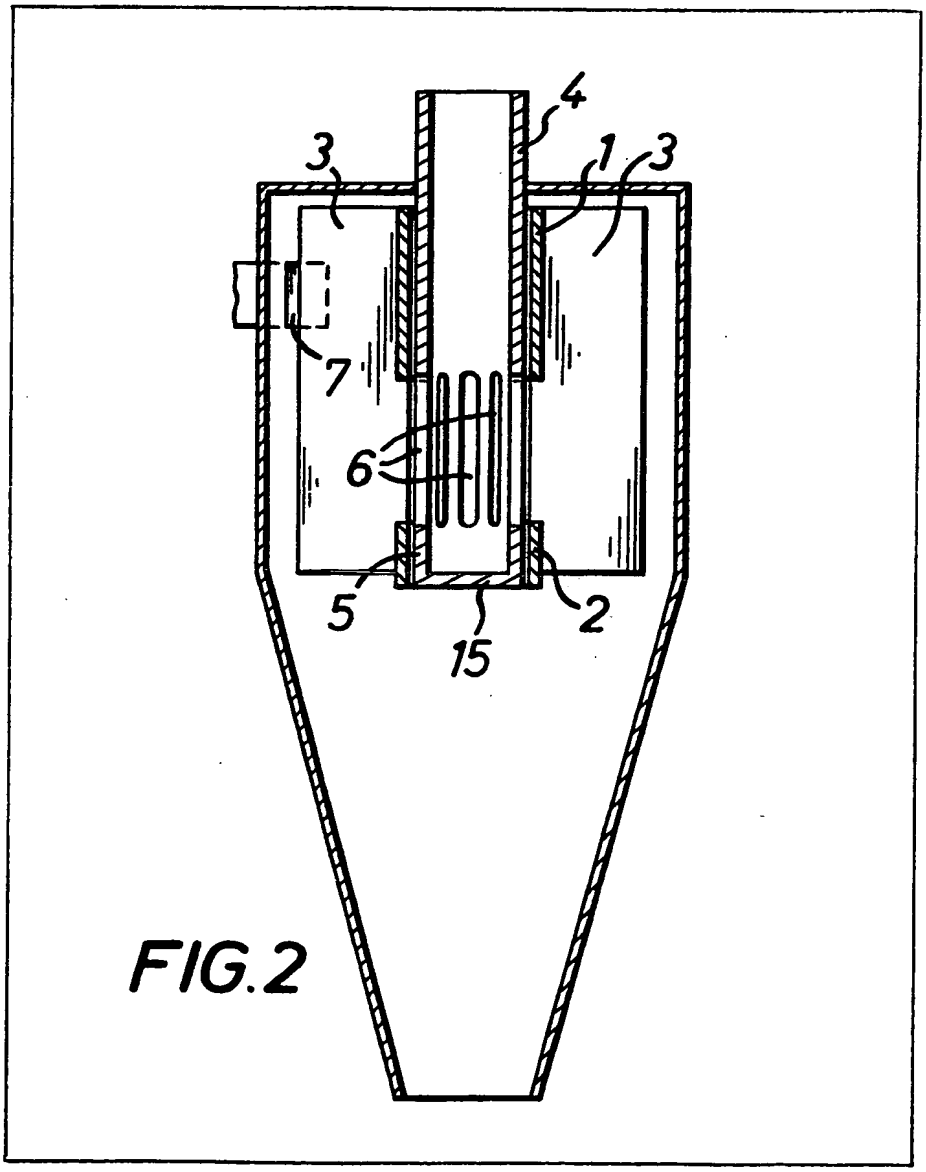

FIG.2

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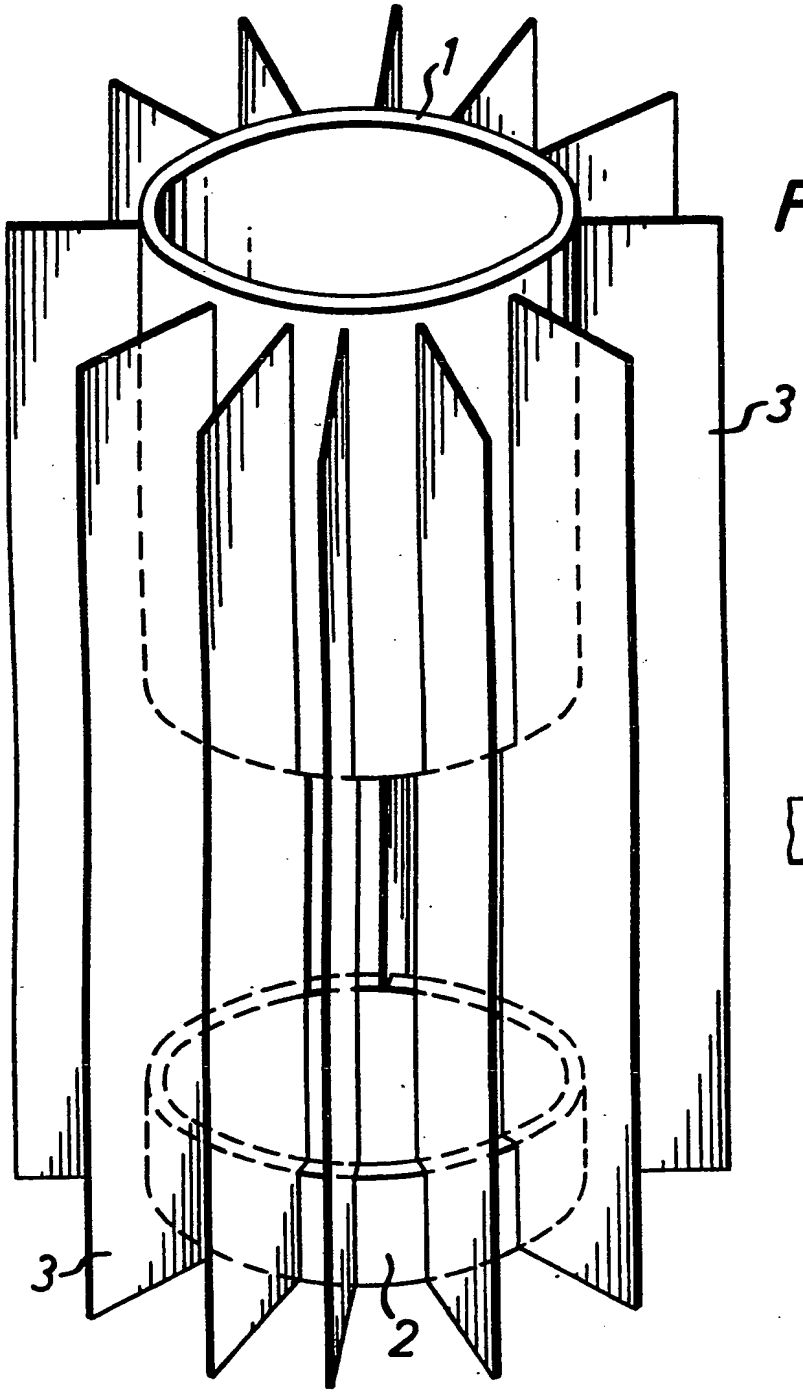

FIG.1

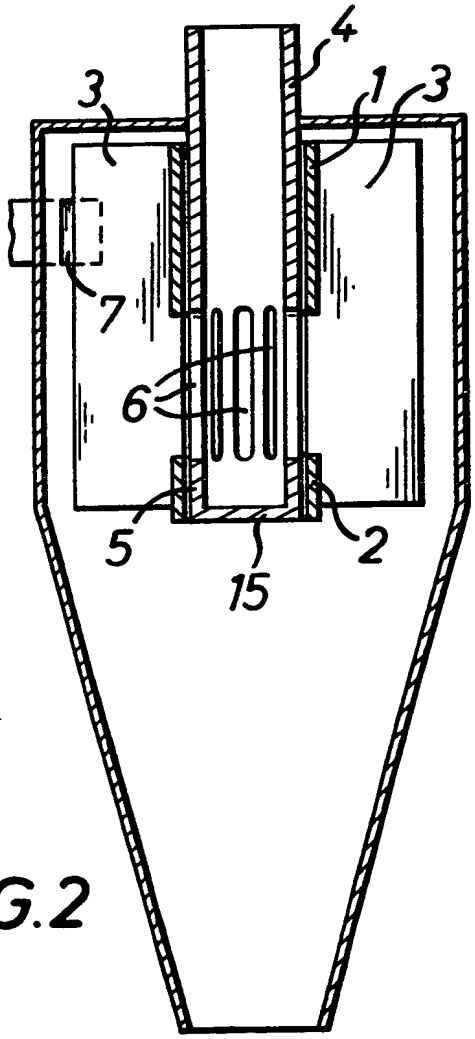

FIG.2

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FIG.3

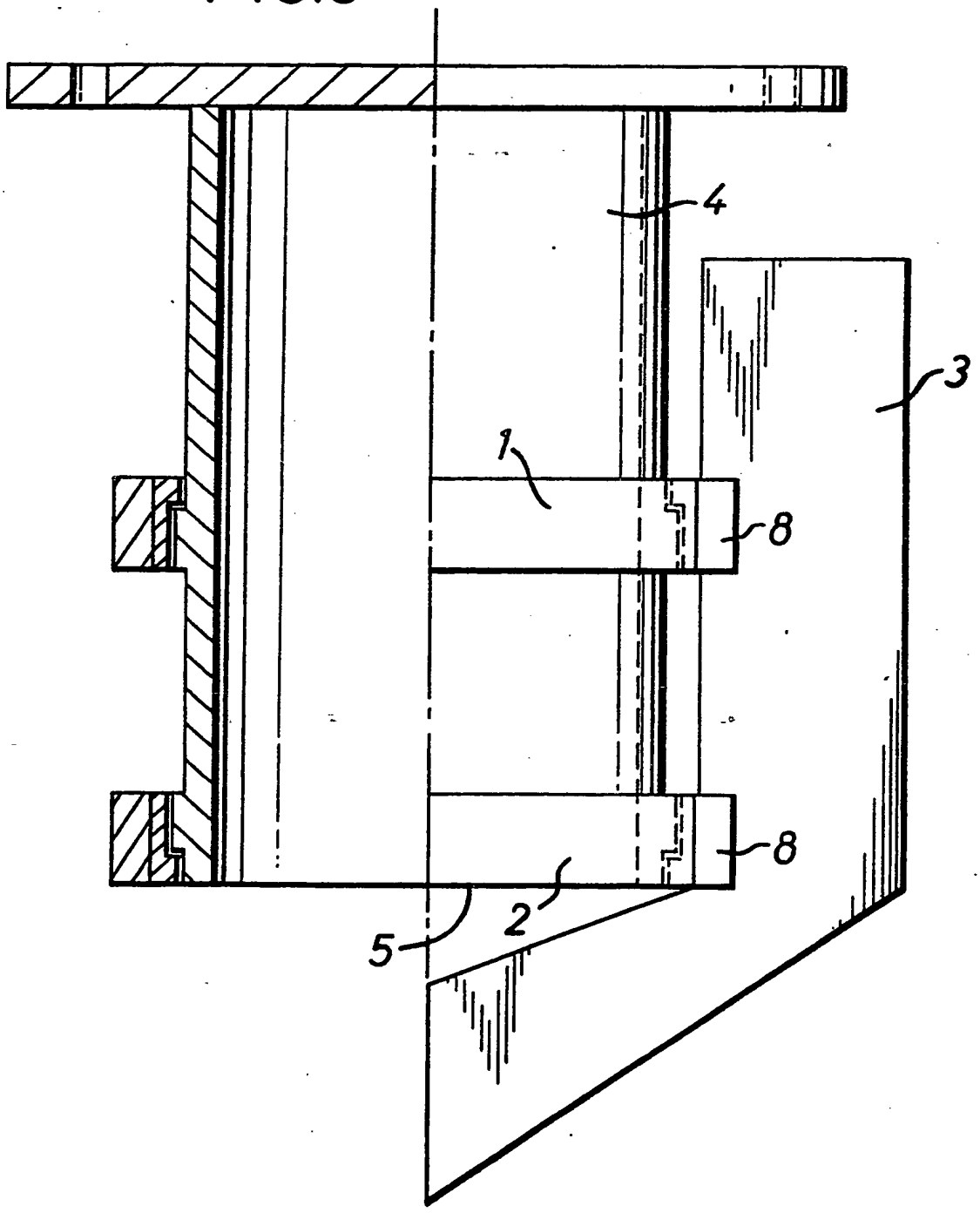

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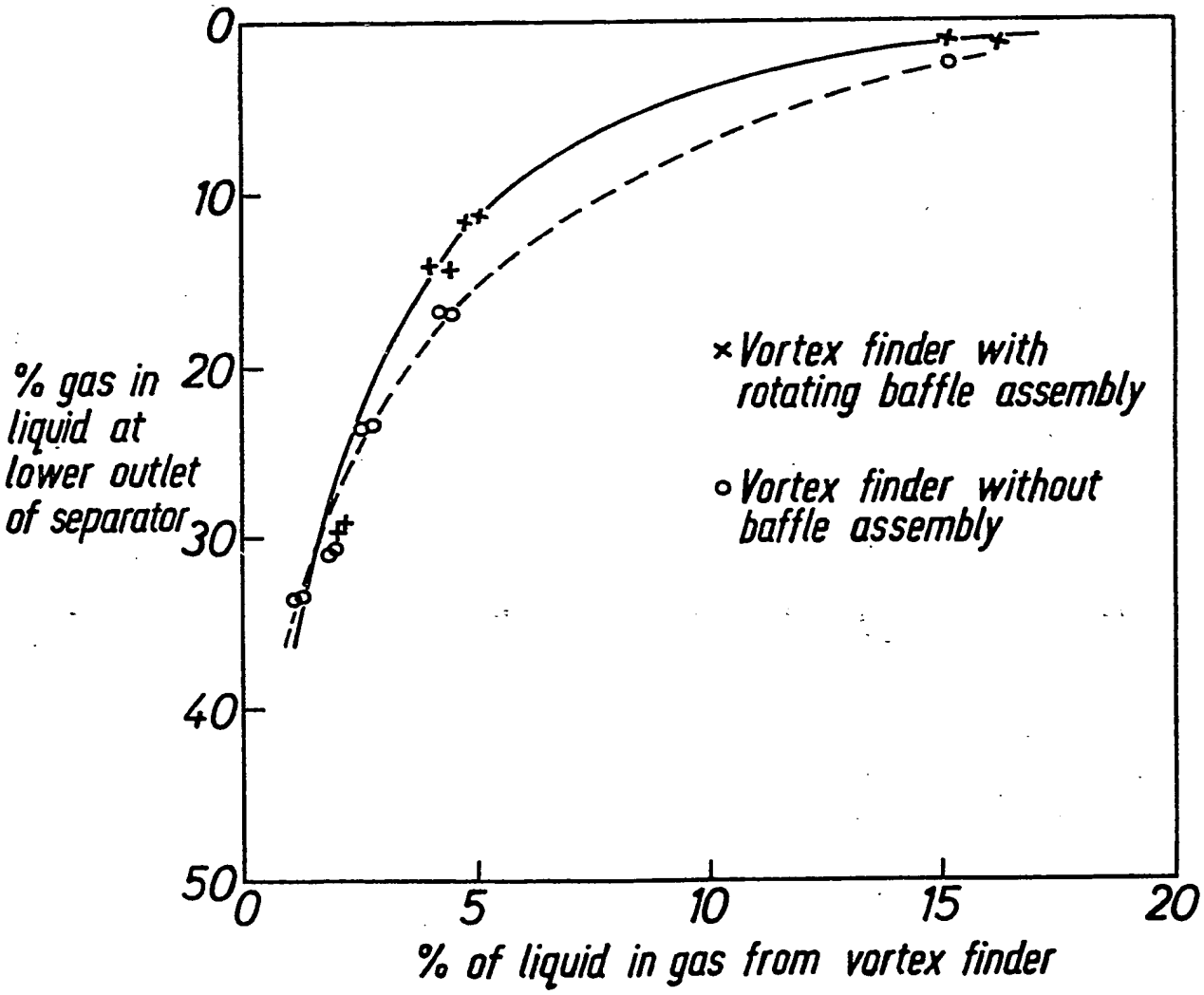
FIG.4



SPECIFICATION

Cyclone

This invention relates to a separator which is suitable for use in the separation of oil and gas.

In our copending patent application No. 27650/78 (Serial No 2000054) there is disclosed a separator for the separation of oil and gas and also a separator system comprising a separator and a gas scrubber connected in series.

An improved separator has now been devised.

According to the present invention there is provided a separator suitable for separating a crude oil feed containing gas into gas and liquid the separator comprising a vessel having an inlet for feed disposed so that feed introduced under a pressure gradient is caused to form a downwardly flowing vortex of enhanced liquid from which gas separates, an upper outlet for the gas comprising a conduit extending downwardly into the vessel from the top thereof herein referred to as a vortex finder, a lower outlet for the enhanced liquid, and wherein the vortex finder has a baffle assembly associated therewith, said baffle assembly being rotatable about a vertical axis.

Conveniently the baffle assembly is rotatable relative to the vortex finder. Alternatively, the baffle assembly and vortex finder can be immovable relative to each other but be rotatable relative to the vessel. The lower end of the vortex finder can be closed and the vortex finder can have a plurality of apertures in the wall thereof for the exit of the gas. The apertures can be in the form of vertically disposed slots and be located wholly below the axis of the inlet.

Preferably the total area of the slots is greater than the cross sectional area of the outlet of the vortex finder to reduce hold up within the vessel.

The baffle assembly can comprise a sleeve mounted on the vortex finder and rotatable relative thereto, the sleeve having the baffle or baffles attached thereto. The baffle assembly can include a second sleeve axially spaced apart from the first mentioned sleeve, the baffle or baffles being attached to the second sleeve. The baffle assembly can comprise one or more baffles and in the case of a plurality of flat baffles they are conveniently radially disposed with respect to the longitudinal axis of the vortex finder, said baffles being in a vertical plane.

In the case of a single baffle a helical configuration is desirable.

The baffles may be of any convenient shape, for example, rectangular, triangular, polygonal or arcuate and may be of linear or curved cross section.

The baffles can be made from or coated with a material of high affinity for either the oil or gas.

The rotation of the baffle assembly can also be used for generating an electrostatic charge within the separator to promote the separation.

The separator in which the rotatable baffle assembly is incorporated can be described in our copending application, 43043/78 claiming priority from UK Patent Application No. 27650/78 Serial No. 2000054.

This application describes a separator suitable for separating a crude oil feed containing gas into gas and liquid which comprises a vessel having an inlet for feed disposed so that feed introduced under a pressure gradient is caused to form a downwardly flowing vortex of enhanced liquid from which an upwardly flowing vortex of enhanced gas separates, an upper outlet for the vortex of enhanced gas comprising a pipe extending downwardly into the vessel from the top thereof referred to as a vortex finder, a lower outlet for the enhanced liquid, the vessel havinf located therein below the inlet a downwardly extending conical surface for the downwardly flowing vortex of enhanced liquid, the walls of the vessel being spaced apart from the conical surface to define therebetween a chamber, referred to as a disengaging chamber, the volume of which is at least equal to the volume defined by the conical surface and having located in the region of the lower end of the conical surface one or more baffles to engage the downwardly flowing vortex of enhanced liquid.

The baffles can be disposed so that they lie in a vertical plane and radially with respect to the longitudinal axis of the vessel.

The conical surface can be provided by the surface of an inverted truncated cone and the baffles can be a plurality extending downwardly from the lower end of the cone.

The disengaging chamber can have a weir to maintain a minimum level in the disengaging chamber, and the conical surface can extend below the level of the top of the weir to provide, in use, a liquid seal at the base of the volume defined by the conical surface.

The separator can have means for controlling the liquid level in the disengaging chamber above the top of the weir, e.g. an adjustable valve in the outlet for controlling the pressure in the outlet.

The ratio of the diameter of the vortex finder to that of the vessel in the region of the inlet can be from 0.40 to 0.80. The vortex finder can extend into the vessel below the axis of the inlet and can conveniently terminate at a level intermediate the axis of the inlet and the conical surface or can extend to the level of the upper end of the conical surface.

References in the present specification to lower, upper and vertical refer to the separator in its disposition for normal use.

The inlet to the vessel is preferably rectangular or square in cross section to assist tangential entry.

Since the feedrate may vary it is desirable to have means for controllably adjusting the size of the inlet comprising an adjustable shutter to restrict the inlet.

To prevent eddying from destroying the vortices created by the tangential entry at low flow rates, the shutter preferably co-operates with a baffle to provide a smoothly converging path to the restricted inlet.

If necessary, provision may be made for injecting a defoaming agent, e.g. a silicone oil, at any convenient point.

The disengaging chamber may be provided by an enlarged lower portion of the vessel.

In the case of a vessel whose horizontal section is circular the diameter of the enlarged portion may be conveniently 1.4 to 2.0 that of the upper portion.

In the present specification the volume within the vessel below where conical surface terminates is considered to be a part of the disengaging chamber.

According to one embodiment of the invention a separator system suitable for separating a feed comprising crude oil containing gas and having a gas:liquid ratio of 2.5:1 to 15:1 by volume at separation conditions into a liquid stream containing no more than 10% gas and a gas stream containing not more than 500 ppm by volume of liquid comprises a separator as hereinbefore described, the vortex finder of which is connected either to (a) a gas scrubber for removing the oil from the gas, or (b) the inlet of a second separator as hereinbefore defined.

The volume of the first separator vessel in relation to the volume of the second separator vessel can be in the range 1.5:1 to 6:1.

The purpose of the gas scrubber or second separator is to remove the droplets of liquid oil from the gas. The gas scrubber can be a vessel containing an oil wettable surface provided, for example, by steel wool, fine wire, rock wool, glass fibre or the like on which surface the droplets of oil collect. The surface can be arranged so that the droplets fall to and collect at the base of the vessel, a particularly convenient surface is provided by a woven steel wool sold under the Trade Name of Knitmesh.

The feed may also contain solids which are normally present in crude oil in the amounts in which they are normally present. Such solids are separated with the liquid oil.

According to another aspect of the invention a process for separating a feed comprising crude oil containing gas into a liquid stream and a gas stream which process comprises:—

(a) passing the feed under a pressure gradient into a first separator as hereinbefore described disposed substantially vertically and forming a downwardly flowing vortex of enhanced liquid from which an upwardly flowing vortex of enhanced gas separates and collecting the enhanced liquid containing not more than 10% gas and

(b) passing the enhanced gas under a pressure gradient into a second separator vessel disposed substantially vertically and forming a downwardly flowing vortex of enhanced liquid from which an upwardly flowing vortex of enhanced gas separates and combining the enhanced liquid separated in the first vessel, and withdrawing the enhanced gas from the second vessel, or

(c) passing the enhanced gas into a gas scrubber to remove liquid therefrom.

The feed may have a gas/liquid ratio of from 2.5:1 to 15:1 and may optionally contain water in amount up to 50% (both amounts being by volume referred to the liquid at separation conditions) and the pressure inside the first vessel can be from 1 to 70 bar absolute and the pressure difference between the vessels can be from 0.1 to 1 bar absolute and inlet velocities to the first and second vessels can be from 6 to 250 m/sec and 50 to 250 m/sec respectively and the process can involve controlling the operating conditions within the ranges specified to obtain a separated gas containing not more than 1 ppm vol of liquid oil and a separated liquid oil containing not more than 10% gas.

In many cases it is preferred to control the inlet velocity to the vessel or both vessels in the range 5 to 100 m/sec to improve vortex formation.

The invention is illustrated with reference to Figures 1 to 4 of the accompanying drawings wherein Figure 1 is a perspective view of the rotatable baffle assembly and Figure 2 is a schematic representation of a separator fitted with the baffle assembly. Figure 3 is a part vertical section of one embodiment of the baffle assembly and Figure 4 is a graph illustrating the improvement in separation achieved by a separator according to the present invention.

In the drawings reference numerals refer to the same parts.

Referring to Figures 1 to 3 the baffle assembly comprises an upper sleeve 1 and a lower sleeve 2 having twelve baffles 3 attached to equally spaced projections 8 of the sleeves.

The shield is mounted on a vortex finder 4 of a separator by upper and lower bearings (not shown). In Figure 2 the end 5 of the vortex finder is closed by cap 15 and slots 6 are provided to permit exit of the lighter component through the vortex finder.

The slots 6 are disposed vertically and are located wholly below the axis of inlet 7.

In Figure 3 the end 5 of the vortex finder is open.

In use, a mixture of crude oil and gas entering tangentially through inlet 7 impinges upon the baffle 3 and causes the assembly to rotate thus making entry of the liquid phase into the slots 6 more difficult.

Referring to Figure 2 the dimensions of the baffle assembly were as follows:

length of each baffle	183 mm
width of each baffle	25 mm
number of baffles	12
internal diameter of vortex finder	22 mm
number of slots	6
length of each slot	50 mm
width of each slot	6 mm

Referring to Figure 4: a separator as shown in Figure 2 was employed at a feed rate of 19.9 m^3/hour, the volume ratio of gas to liquid oil was 4.9:1. The percentage of gas in the liquid at the lower outlet of the separator was plotted against the percentage of liquid in the gas from the vortex finder. An otherwise identical separator but without the baffle assembly and whose vortex finder was open at the lower end, as described in our copending UK Patent application 43043/78 claiming priority from application No. 27650/78, was employed under identical conditions.

Figure 4 shows the improvement in separation effected by the separator which had the rotatable baffle assembly.

CLAIMS

1. A separator suitable for separating a crude oil feed containing gas into gas and liquid the separator comprising a vessel having an inlet for feed disposed so that feed introduced under a pressure gradient is caused to form a downwardly flowing vortex of enhanced liquid from which gas separates, an upper outlet for the gas comprising a conduit extending downwardly into the vessel from the top thereof herein referred to as a vortex finder, a lower

outlet for the enhanced liquid, and wherein the vortex finder has a baffle assembly associated therewith, said baffle assembly being rotatable about a vertical axis.

2. A separator as claimed in claim 1 wherein the baffle assembly is rotatable relative to the vortex finder.

3. A separator as claimed in claim 1 wherein the baffle assembly and vortex finder are immovable relative to each other and are rotatable relative to the vessel.

4. A separator as claimed in any one of the preceding claims wherein the lower end of the vortex finder is closed and the vortex finder has a plurality of apertures in the wall thereof for the exit of the gas.

5. A separator as claimed in claim 4 wherein the apertures are in the form of vertically disposed slots and are located wholly below the axis of the inlet.

6. A separator as claimed in claim 1 wherein the baffle assembly comprises a sleeve mounted on the vortex finder and rotatable relative thereto, said sleeve having the baffles attached thereto.

7. A separator as claimed in claim 6 having a second sleeve axially spaced apart from the first mentioned sleeve, the baffles being attached to said second sleeve.

8. A separator as claimed in any one of the preceding claims wherein the baffle assembly comprises a plurality of baffles symmetrically located and radially disposed with respect to the longitudinal axis of the vortex finder, said baffles being in a vertical plane.

9. A separator system suitable for separating a feed comprising crude oil containing gas and having a gas:liquid ratio of 2.5:1 to 15:1 by volume at separation conditions into a liquid stream containing no more than 10% gas and a gas stream containing not more than 500 ppm by volume of liquid comprises a separator as hereinbefore described, the vortex finder of which is connected either to (a) a gas scrubber for removing oil from the gas, or (b) the inlet of a second separator, as claimed in any one of claims 1 to 8.

10. A process for separating a feed comprising crude oil containing gas into a liquid stream and a gas stream which process comprises:—

(a) passing the feed under a pressure gradient into a first separator as hereinbefore described disposed substantially vertically and forming a downwardly flowing vortex of enhanced liquid from which an upwardly flowing vortex of enhanced gas separates and collecting the enhanced liquid containing not more than 10% gas and

(b) passing the enhanced gas under a pressure gradient into a second separator vessel disposed substantially vertically and forming a downwardly flowing vortex of enhanced liquid from which an upwardly flowing vortex of enhanced gas separates and combining the enhanced liquid separated in the first vessel, and withdrawing the enhanced gas from the second vessel, or

(c) passing the enhanced gas into a gas scrubber to remove liquid therefrom.

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